# A DOOR LOCK APPARATUS FOR A VEHICLE

This application is based on and claims priority under 35 U.S.C. § 119 with respect to Japanese Application No. 2003-040000 filed on February 18, 2003, the entire contents of which are incorporated herein by reference.

## FIELD OF THE INVENTION

**[0001]** The present invention generally relates to a vehicle door lock apparatus.

## BACKGROUND OF THE INVENTION

**[0002]** A known door lock apparatus for a vehicle is disclosed in US4762348. According to an electric door lock system disclosed in the above patent, includes a box-shaped case member to which a rotating plate having a substantially circular shape is supported. The rotating plate can be driven in a clockwise direction and a counterclockwise direction by a motor. An output member having a fan shape is connected to one side face of the rotating plate. When the motor drives to rotate the rotating plate in the counterclockwise direction by an operation of a relay in response to the operation of the inside switch by the user for opening the door, the output member pulls a rod for opening the door via an arm. Then, a pawl is rotated in a direction in which the engagement between the pawl and a latch is disengaged. The latch is subsequently rotated to an open position of the door and the unlock operation is completed accordingly. Meanwhile, when the motor drives to rotate the rotating plate in the clockwise direction by operations of a half-latch sensor

and a relay in response to the closing operation of the door to the half-latched position, the output member pulls a rod for closing the door via the other arm. Then, the latch is rotated to a full-latched position, and the door lock operation is completed accordingly. A neutral position sensor whose contact is retained in closed state by a circumferential face of the rotating plate is provided in the case member. When a concave portion formed on the other side face of the circumferential face of the rotating plate is moved to a portion where the neutral position sensor is positioned by the rotation of the rotating plate, the contact of the neutral position sensor becomes in open state. The rotating plate is constituted to return to the neutral position side by the motor so that the rotating plate can start the following lock operation, for example, in case that the unlock operation is performed. When the contact of the neutral position sensor is turned in the open state with the concave portion being positioned at the neutral position sensor, the motor is stopped by the operation of the relay to prepare for the following operation (same return operation is performed in case of the lock operation).

**[0003]** According to the above-mentioned disclosed door lock apparatus, however, the following problems may occur. The motor is sopped based on the switching of the neutral position sensor to the open state when the rotating plate is returned to the neutral position at a time of the completion of the lock operation or the unlock operation. Thus, if the concave portion is set short in length in the circumferential direction of the rotating plate for precisely defining the neutral position, the neutral position sensor tends to be positioned out of the concave portion when the rotating plate overruns with the motor and then the standby state is initiated in that state. In this case, the neutral

position sensor is in the closed status eve if the door is open. This fails to satisfy the condition that all sensors are in open state under the door being open, which is disclosed in the above Japanese Publication. The lock operation is possibly not performed since the relay is not operated and thus the motor is not supplied with power even if the half-latch sensor becomes in closed state by the door being closed to the half-latched position. Further, if the concave portion is set longer in length in the circumferential direction of the rotating plate so that the neutral position sensor is positioned within the concave portion even by the overrun of the motor, the neutral position range becomes too wide. This may cause the output member to start pulling the rod for unlocking the door, for example, when the rotating plate is returned to the neutral position upon completion of the lock operation, or the delay of the lock operation or the unlock operation to start. Especially when the user operates the inside switch for opening the door and therefore the rotating plate is rotated in the counterclockwise direction, first the neutral position sensor is required to reach one end portion from the other end portion of the long concave portion. Then, when the neutral position sensor becomes positioned out of the concave portion by the rotation of the rotating plate, the output member finally starts the unlock operation. Accordingly, a relatively long time-lag may occur until the door is actually opened, thereby causing the user to feel uncomfortable. In order to obtain the certainty of each operation, the length of the concave portion, within which the neutral position sensor remains to be positioned even by the overrun of the motor, cannot be surely defined by matching the length of the concave portion to the overrun of the

motor that is objectively predicted. The predicted length is further required to be multiplied by a safety factor.

**[0004]** Thus, a need exists for a door lock apparatus for a vehicle which can surely perform the lock operation and the unlock operation. Further, a need exists for the vehicle door lock apparatus for the vehicle that can decrease a time-lag from the command signal output to a start of the lock operation or the unlock operation with a simple structure to thereby provide a more comfortable feeling to the user.

## SUMMARY OF THE INVENTION

**[0005]** According to an aspect of the present invention, a door lock apparatus for a vehicle includes a latch provided at one of a vehicle door and a vehicle-body and being rotatable between an open position in which the latch is disengageable from a striker provided at the other one of the vehicle door and the vehicle-body and a lock position in which the latch is prohibited to disengage from the striker, and an operating member for performing one of a lock operation for rotating the latch to the lock position and an unlock operation for rotating the latch to the open position by being moved from a neutral position to a first position by a driving source, and performing the other one of the lock operation and the unlock operation by being moved from the neutral position to a second position opposite to the first position relative to the neutral position by the driving source. The vehicle door lock apparatus also includes a control unit for switching a moving direction of the operating member driven by the driving source so that the operating member alternately

performs the lock operation and the unlock operation, an operated member for being operated along with the operating member moved to the second position, a restricting member for restricting a movement of the operated member in a predetermined position when the operating member is moved to the first position, a detecting means for detecting the operated member being positioned adjacent to the predetermined position, and a housing for accommodating the latch, the operating member, the control unit, the operated member, the restricting member, and the detecting means. The control unit enters a standby mode through a process of bringing the operating member to return to the second position side after one of the lock operation and the unlock operation is completed so that the operated member is not detected by the detecting member, and enters the standby mode through a process of bringing the operating member to return to the first position side after the other one of the lock operation and the unlock operation is completed so that the operate member is detected by the detecting means.

## BRIEF DESCRIPTION OF THE DRAWING FIGURES

**[0006]** The foregoing and additional features and characteristics of the present invention will become more apparent from the following detailed description considered with reference to the accompanying drawing figures in which like reference numerals designate like elements.

**[0007]** Fig. 1 is a side view of a rear portion of a vehicle equipped with a vehicle door lock apparatus according to an embodiment of the present invention;

[0008] Fig. 2 is a cross-sectional view of the vehicle door lock apparatus in a full-latched state;

[0009] Fig. 3 is a plain view of the vehicle door lock apparatus of Fig. 1;

[0010] Fig. 4 is a front view of the vehicle door lock apparatus of Fig. 1;

[0011] Fig. 5 is a front view showing a portion of the vehicle door lock apparatus of Fig. 3;

[0012] Fig. 6 is a cross-sectional view showing a portion of the vehicle door lock apparatus of Fig. 4;

[0013] Fig. 7 is a view for explaining a process of a door lock operation (and a door unlock operation);

[0014] Fig. 8 is a view for explaining a process of the door lock operation;

[0015] Fig. 9 is a view for explaining a process of the door lock operation;

[0016] Fig. 10 is a view for explaining a process of the door lock operation;

[0017] Fig. 11 is a view for explaining a process of the door lock operation (and the door unlock operation);

[0018] Fig. 12 is a view for explaining a process of the door unlock operation;

[0019] Fig. 13 is a view for explaining a process of the door unlock operation;

[0020] Fig. 14 is a block view showing a control unit; and

[0021] Fig. 15 is a view for explaining each process of the door lock operation and the door unlock operation.

## DETAILED DESCRIPTION OF THE INVENTION

[0022] An embodiment of the present invention is explained referring to attached drawings. Figs. 1 and 2 show a door opening/closing mechanism 100 disposed between a body 1 and a door 3 (back door in the present embodiment)

of a vehicle. The door opening/closing mechanism 100 includes a striker 2 provided at the door 3 and a door lock mechanism 4 provided in the vicinity of a rear edge portion of a floor of the body 1 as shown in Fig. 1. An open handle 3a is provided at an outboard side of the door 3. As shown in Fig. 3, the door lock mechanism 4 includes a synthetic-resin housing 5, a plate-shaped latch 6 that can pull the striker 2 into the body 1 side, a pawl 7 for restricting a rotation of the latch 6, and a lock operation mechanism 8 for locking or unlocking the door 3 via a motor-powered operation of the latch 6 and the pawl 7. The housing 5 includes a housing body 5a and a base 5b for covering the housing body 5a from an upper side of the vehicle as shown in Fig. 6 in detail. A concave portion 5c is formed on the base 5b for receiving the striker 2.

[0023] As shown in Figs. 3 to 6, the latch 6 is rotatably supported on a shaft X1 provided perpendicularly on the base 5b of the housing 5. The latch 6 is biased in an arrow A1 direction by a coil spring SP1 and the like having a relatively strong biasing force toward a home position HP1 (state in Fig. 7, i.e. an example of open position). The latch 6 includes a first projection 6a provided close to an outer side of the body 1, i.e. on a side close the door 3, and a second projection 6b provided close to an inner side of the body 1, i.e. on a side away from the door 3. An engaging groove 6g for receiving the striker 2 is formed between the projections 6a and 6b. In addition, a half-engaging face 6h is formed on an inner side of the second projection 6b, i.e. a side close to the engaging groove 6g, of the latch 6 and pressed against an operating piece 7a of the pawl 7 in a half-latched position. In addition, a full-engaging face 6f is provided on an outer side of the first projection 6a, i.e. a side close to the door 3, and pressed against the operating piece 7a of the pawl 7 in a full-latched

position. The latch 6 further includes a third projection 6c (operated portion) for receiving the lock operation by a closure arm 12 of the lock operation mechanism 8 (to be explained later). The third projection 6c is formed with an engaged concave portion 6k with which an operating pin 12a (to be explained later) is engageable. In the home position HP1, the third projection 6c is pressed against a cushion-shaped stopper 51a provided on the housing body 5a by a biasing force of the coil spring SP1.

**[0024]** A detected piece 6p (see Fig. 6) is provided at the latch 6, being integrally rotatable therewith for detecting a rotation status of the latch 6 as a rotation status detecting mechanism. A rotary switch SW1 (see Fig. 5) (control unit) is provided on the housing 5 for electrically detecting the detected piece 6p. The rotary switch SW1 includes a first contact Q1 (half-latch switch) for detecting the latch 6 in the half-latched state, a second contact Q2 (full-latch switch) for detecting the latch 6 in the full-latched state, and a third contact Q3 for grounding. The pawl 7 is rotatably supported on a shaft X2, which is substantially perpendicularly provided on the base 5b, between a first position ST (see Fig. 5) and a second position RT (see Fig. 13). In the first position ST, the operating piece 7a of the pawl 7 is positioned within a rotation locus of the first projection 6a or the second projection 6b. In the second position RT, the operating piece 7a is not positioned within the rotation locus of the first projection 6a or the second projection 6b. The pawl 7 is biased to return to the first position ST by a biasing force of a coil spring SP2. In the first position ST, the operating piece 7a is in contact with the half-engaging face 6h or the full-engaging face 6f to thereby prevente the latch 6 from returning to the home position HP1. In the second position RT, the latch 6 is permitted to return to

the home position HP1. Further, in the first position ST, an end portion of the pawl 7 provided on an opposite side to the operating piece 7a with respect to the shaft X2 is pressed against a stopper 51b provided on the housing 5 by the biasing force of the coil spring SP2. An operated piece 7b is also arranged on radially outer side relative to the operating piece 7a with respect to the shaft X2.

**[0025]** The lock operation mechanism 8 includes a closing mechanism 8a for the lock operation of the door 3 and an opening mechanism 8b for the unlock operation of the door 3. The lock operation mechanism 8 also includes an origin switch SW2 (detecting means) provided on the housing body 5a for controlling a switching between the lock operation and the unlock operation. The closing mechanism 8a includes a first swing lever 11 (operating member) rotatably supported on a shaft X3 provided on the base 5b and the closure arm 12 (closure member) rotatably connected to a vicinity of a tip portion of the first swing lever 11 via a pin. The operating pin 12a extending substantially parallel to the shaft X3 is integrally formed on a vicinity of a tip portion of the closure arm 12. In addition, a smooth guide face 14 is provided on the housing body 5a for specifying a locus of the operating pin 12a in a predetermined shape. A coil spring SP3 is provided between the closure arm 12 and the first swing lever 11 for pushing the operating pin 12a toward the guide face 14 by biasing the closure arm 12 in a counterclockwise direction in Fig. 5. The first swing lever 11 is supported on a driving shaft 10, which is rotated in an arrow C1 or C2 direction by a rotation force transmitted from an electric motor M, such that the first swing lever 11 cannot rotate relative to the driving shaft 10. The rotation force of the electric motor M is transmitted to the driving shaft 10

via a worm gear fixed to a rotation shaft of the electric motor M, a third gear into which the driving shaft 10 is disposed, and a deceleration mechanism including a first gear and a second gear engaging with each other and arranged between the worm gear and the third gear. The third gear G3 and a portion of the second gear G2 are only shown in Fig. 6. A biasing force of the coil spring SP3 disposed between the closure arm 12 and the first swing lever 11 is set to a sufficient level so that the operating pin 12a is constantly pressed against the guide face 14 regardless of a position of the lock operation mechanism 8 in the vehicle or a moving distance of the operating pin 12a on the guide face 14. At the same time, if an object that prevents a sliding of the operating pin 12a on the guide face 14, such as an edge portion of the third projection 6c of the latch 6, instead of the engaged concave portion 6k, is positioned in the vicinity of the guide face 14 due to a malfunction of a CPU (control unit) caused by a noise and the like, the operating pin 12a is able to slide on the guide face 14 by detouring around the object, i.e. moving beyond the object, so that the closure arm 12, the guide face 14 and the like are not damaged.

[0026] When the driving shaft 10 is kept rotating in the arrow C1 direction along with a normal rotation of the electric motor M, the first swing lever 11 is rotated as a unit with the driving shaft 10. Then, the operating pin 12a of the closure arm 12 is slid to move on the guide face 14 and engages with the engaged concave portion 6k (operated portion) formed on the third projection 6c of the latch 6, thereby rotating the latch 6 in an arrow A2 direction. The latch 6 becomes in a full-latched state as shown in Figs. 5 and 11. The guide face 14 is formed by a first guide region 14a constituted by a portion of a first

arc provided with respect to the shaft X3 and a second guide region 14b constituted by a portion of a second arc provided with respect to the shaft X1 being smoothly connected with each other via an inflection portion 14Y having a short (equal to or smaller than 5mm, for example) or no length. A radius of the second arc forming the second guide region 14b is set to a value whereby the operating pin 12a is constantly positioned on the rotation locus of the engaged concave portion 6k of the latch 6 moving with respect to the shaft X1 as long as the operating pin 12a is positioned on the second guide region 14b. When the operating pin 12a is positioned on the inflection portion 14Y, the operating pin 12a faces extremely close to the engaged concave portion 6k or is slightly in contact therewith. A radius of the first arc forming the first guide region 14a is slightly larger than that of the second arc and does not overlap with the rotation locus of the engaged concave portion 6k of the latch 6 as long as the operating pin 12a is positioned on the first guide region 14a (for example, a state in Fig. 5) in which the inflection portion 14Y is excluded.

[0027] The opening mechanism 8b includes an unlock plate 20 (operated member) slidably supported on the shaft X3. The unlock plate 20 is supported on the driving shaft 10 so as to rotate relative thereto, which is a different condition from the first swing lever 11. The unlock plate 20 is biased in an arrow D1 direction in Fig. 5 by a coil spring SP4 (biasing member) disposed between the unlock plate 20 and the housing body 5a. As shown in Figs. 5 and 6, the unlock plate 20 includes a supported portion 20a supported by the driving shaft 10 and from which a second swing lever portion 22 and a first control lever portion 24 extend as a unit with the supported portion 20a in different directions from each other. A release arm 30 (release member) is

rotatably connected to a vicinity of a tip portion of the second swing lever portion 22 via a pin for releasing the pawl 7, i.e. disengaging the pawl 7 from the latch 6. As shown in Fig. 7, the release arm 30 includes a base end portion 30a rotatably supported on the second swing lever portion 22, a middle portion 30b extending in a transverse direction in Fig. 7 from the base end portion 30a, and an operating portion 30c extending obliquely upward from the middle portion 30b. A guide hole 31 is formed on the middle portion 30b and in which a control pin 53 perpendicularly formed on the housing body 5a is positioned. Thus, a link mechanism is constituted by the base end portion 30a of the release arm 30 rotatably supported on the second swing lever portion 22 and the guide hole 31 whose moving area is restricted only in a substantially transverse direction in Fig. 7 by the control pin 53. When the unlock plate 20 is rotated in an arrow D2 direction (i.e., counterclockwise direction) in Fig. 5, the operating portion 30c of the release arm 30 is moved to the pawl 7 side according to the link mechanism.

[0028] In addition, as shown in Fig. 5, a second control lever portion 23 extends laterally and integrally from a vicinity of a base end portion of the second swing lever portion 22. An operated piece 23a engageable with the first swing lever 11 of the closing mechanism 8a is perpendicularly formed on an edge portion of the second control lever portion 23. When the driving shaft 10 is rotated in the arrow C2 direction due to a reverse rotation of the electric motor M, the first swing lever 11 rotated in the same direction, i.e. the arrow C2 direction, pushes and operates together with the operated piece 23a. Then, the unlock plate 20 is rotated in the arrow D2 direction by overcoming the biasing

force of the coil spring SP4. Finally, the release arm 30 releases the pawl 7, i.e. disengages the pawl 7 from the latch 6.

[0029] A restricted piece 24a is formed perpendicularly in the vicinity of a tip portion of the first control lever portion 24. Then, a cushion-shaped stopper 51c (restricting member) is provided on the housing body 5a, being partially positioned within the rotation locus of the restricted piece 24a. That is, the rotation of the unlock plate 20 by the coil spring SP4 in the D1 direction is restricted by the restricted piece 24a being in contact with the stopper 51c.

[0030] A switch operating portion 25 for pressing the origin switch SW2 extends laterally from a vicinity of the base end portion of the first control lever portion 24 as shown in Fig. 5. A position relationship between the origin switch SW2 and the switch operating portion 25 is that the switch operating portion 25 presses the origin switch SW2 to turn in ON status immediately before the restricted piece 24a of the first control lever portion 24 becomes in contact with the stopper 51c while the unlock plate 20 is rotated in the D1 direction.

[0031] The vehicle is equipped with an ECU (electronic control unit). As shown in Fig. 14, the CPU provided in the ECU sends a command signal of normal rotation, reverse rotation or stop to the electric motor M based on a status of the origin switch SW2 (ON or OFF) after receiving a signal from a microswitch 3s (that sends a release signal) provided at the open handle 3a of the door 3, the half-latch switch Q1, the full-latch switch Q2 (each indicates switching state of the rotation of the latch 6), and the origin switch SW2 (that indicates a present status of the door lock mechanism 4).

[0032] Next, the lock operation and the unlock operation by the door opening/closing mechanism 100 are explained as follows based on main processes. Fig. 15 is a diagram showing each status of the latch 6 (open, half-latch, or full-latch), the electric motor M (normal rotation, reverse rotation or stop), and the origin switch SW2 (ON or OFF) in each operation of the door 3 based on the passage of time. Each process (L0 to L5, and U0 to U4) is indicated radially inner side of a ring showing a status of the electric motor M. A length in a circumferential direction of each process, however, does not correspond to time required for an actual situation.

[0033] The lock operation of the door 3 by the closing mechanism 8a of the door opening/closing mechanism 100 is performed based on each process mentioned below.

L0( as shown in Fig. 15): door open state

[0034] When the door 3 is open, the latch 6 is in the home position HP1 in which the third projection 6c of the latch 6 is pressed against the stopper 51a. The pawl 7 is in the first position ST in which the end portion of the pawl 7 provided opposite side to the operating piece 7a with respect to the shaft X2 is pressed against the stopper 51b. The first swing lever 11 of the closing mechanism 8a is stopped in a position whereby the switch operating portion 25 of the unlock plate 20 keeps the origin switch SW2 in ON status (i.e. home position HP2). At this time, the restricted piece 24a of the first control lever portion 24 can be pressed against the stopper 51c. In addition, at this time, the operating pin 12a of the closure arm 12 is positioned out of the rotation locus of the third projection 6c of the latch 6. This state is a preliminary step

before the substantial door lock operation is initiated. The substantial door lock operation is initiated from a next process.

L1( as shown in Fig. 15): obtaining the half-latched state

[0035] When the user slightly manually closes the door 3 from the door open state mentioned above, the second projection 6b of the latch 6 is pushed by the striker 2 of the door 3 to thereby rotate the latch 6 in the A2 direction by overcoming the biasing force of the coil spring SP1. The second projection 6b is kept rotating to push the pawl 7 toward the second position RT. Finally, when the second projection 6b is once positioned above the operating piece 7a of the pawl 7, the latch 6 becomes in the half-latched state by the pawl 7 returning to the first position ST and the operating piece 7a of the pawl 7 engaging with the half-engaging face 6h as shown in Fig. 8. At this time, the detected piece 6p of the latch 6 is detected by the first contact Q1 of the rotary switch SW1. An electrical signal indicating the half-latched state (in the door lock operation) (indicated as "occurrence of the half-latch signal" in Fig. 15) is sent from the rotary switch SW1 and received by the CPU, which then sends the control signal to the electric motor M to rotate the motor in the normal rotation direction.

L2( as shown in Fig. 15): staring to pull the striker into the latch

[0036] When the first swing lever 11 is rotated in the C1 direction (clockwise direction) together with the driving shaft 10 from the home position HP2 due to the normal rotation of the electric motor M that has been started at the end of the L1 process, the operating pin 12a of the closure arm 12 is slid to move on the guide face 14. The operating pin 12a engages with the third projection 6c

of the latch 6 in a position where the operating pin 12a just passes over the inflection region 14Y. Then, as shown in Fig. 9, the operating pin 12a is kept sliding on the second guide region 14b, thereby rotating the latch 6 in the A2 direction. As a result, the striker 2 engaged within the engaging groove 6g starts to be pulled into the concave portion 5c of the housing 5.

L3( as shown in Fig. 15): full-latch preparing state

[0037] When the first swing lever 11 is kept rotating by the normal rotation of the electric motor M and the operating pin 12a is slid on a last half portion of the second guide region 14b to thereby rotate the latch 6 in the A2 direction, the first projection 6a of the latch 6 then rotates the pawl 7 towards the second position RT. Finally, when the first projection 6a is once positioned above the operating piece 7a of the pawl 7, the latch 6 becomes in the full-latch preparing state by the pawl 7 returning to the first position ST and the operating piece 7a of the pawl 7 facing the full-engaging face 6f. The first swing lever 11 is still kept rotating by the normal rotation of the electric motor M to the next process. The full-latch preparing step is included in the full-latch state in the broad sense.

L4( as shown in Fig. 15): over-stroke process

[0038] When the first swing lever 11 is kept rotating by the normal rotation of the electric motor M and the operating pin 12a is slid on the last half portion of the second guide region 14b to thereby further rotate the latch 6 in the A2 direction, the over-stroke process in which the first projection 6a of the latch 6 becomes once separated from the operating piece 7a is obtained as shown in Fig. 10. At this time, the detected piece 6p is detected by the second contact

Q2 of the rotary switch SW1. Then, an electrical signal indicating the full-latched state is sent from the rotary switch SW1 and received by the CPU, which then stops the motor M once. Then the motor M sends the control signal for rotating the electric motor M in the reverse rotation direction. The over-stroke process is included in the full-latched state in the broad sense.

L5(as shown in Fig. 15): return process of the closing mechanism to the original position

[0039] The first swing lever 11 is started to be rotated in the C2 direction due to the reverse rotation of the electric motor M. When the operating pin 12a returns to move slightly on the second guide region 14b toward the first guide region 14a, the latch 6 is rotated in the A1 direction by the biasing force of the coil spring SP1, thereby obtaining the actual full-latched state (not shown) in which the first projection 6a is in contact with the operating piece 7a of the pawl 7 again and the operating pin 12a is separated from the third projection 6c of the latch 6. Next, the reverse rotation of the electric motor M is further continued and thus the operating pin 12a enters into the first guide region 14a. Finally, when the first swing lever 11 presses the second control lever portion 23 slightly in the D2 direction, the restricted piece 24a of the first control lever portion 24 becomes slightly separated from the stopper 51c as shown in Fig. 11. The switch operating portion 25 turns the origin switch SW2 in OFF status subsequently. The CPU stops the electric motor M based on the signal output from the origin switch SW2 (indicating completion of the lock operation) at a time of the origin switch SW2 turned in OFF status. Then, the CPU enters into a standby mode.

[0040] In the standby mode, the unlock plate 20 may be constituted to be further pushed in the D2 direction by the overrun of the first swing lever 11 and stopped in a position whereby the switch operating portion 25 becomes separated from an operated piece of the origin switch SW2 during a time-lag (corresponding to an overrun amount OL of the electric motor M shown in Fig. 15) from a time of the origin switch SW2 turned in OFF status to a time of the electric motor M actually stopped. In this case, however, if the switch operating portion 25 is widely separated from the origin switch SW2, the following unlock operation by the opening mechanism 8b is slightly delayed to start. Therefore, the overrun amount OL is desirably reduced so that the distance between the switch operating portion 25 and the origin switch SW2 is minimized. In the standby mode, it should be noted that the operating pin 12a of the closure arm 12 is positioned out of the rotation locus of the third projection 6c of the latch 6.

[0041] The unlock operation of the door 3 by the opening mechanism 8b of the door opening/closing mechanism 100 is performed according to each process in the following.

U0( as shown in Fig. 15): door closed state

[0042] When the door 3 is closed, the door opening/closing mechanism 100 is in the same state as a final stage of the L5: return process of the closing mechanism to the original position as shown in Fig. 11. That is, the latch 6 is in the full-latched state as the full-engaging face 6f is pressed against the operating piece 7a of the pawl 7. In addition, the first swing lever 11 of the closing mechanism 8a presses the second control lever portion 23 in the D2 direction to thereby obtain a small clearance between the restricted piece 24a

of the first control lever portion 24 and the stopper 51c. That is, the origin switch SW2 is not pressed by the switch operating portion 25 of the unlock plate 20 and is in OFF status. This state is a preliminary step before the door unlock operation is actually initiated. The substantial door unlock operation is initiated from a next process.

U1( as shown in Fig. 15): staring operation of the release arm 30

**[0043]** When the open handle 3a provided at the outside of the door 3, an open lever (not shown) provided at a driver seat or the like is operated from the above-mentioned state, the release signal (shown as "occurrence of release signal" in Fig. 15) is sent to the CPU from the microswitch 3s operated together with the open handle 3a. The CPU then sends a control signal for rotating the electric motor M in the reverse rotation direction. The first swing lever 11 is rotated in the C2 direction (counterclockwise direction) from the home position HP2 side as shown in Fig. 12. Then, the second control lever portion 23 of the unlock plate 20, which engages with the first swing lever 11 via the operated piece 23a, is moved in the D2 direction, thereby moving the release arm 30 rotatably connected to the second swing lever portion 22 toward the pawl 7 by the aforementioned link mechanism.

U2( as shown in Fig. 15): releasing of the pawl 7

**[0044]** The operating portion 30c of the release arm 30 starts to be in contact with the operated piece 7b of the pawl 7 to thereby rotate the pawl 7 in a B2 direction as the reverse rotation of the electric motor M is continued. When the pawl 7 is moved to the second position RT, the operating piece 7a of the pawl 7 becomes out of the rotation locus of the first projecting 6a of the latch 6.

Thus, the latch 6 is disengaged and released from the pawl 7 and started to return to the A1 direction toward the home position HP1. This returning process of the latch 6 is performed at the same time as the latch 6 brings the striker 2 to be outwardly withdrawn from the concave portion 5c of the base 5b by the biasing force of the coil spring SP1.

U3( as shown in Fig. 15): obtaining the half-latched state

**[0045]** When the latch 6 reaches the half-latched position during the above-mentioned returning process, the detected piece 6p of the latch 6 is detected by the first contact Q1 of the rotary switch SW1. Then, an electrical signal indicating the half-latched state (in the door unlock operation) is sent from the rotary switch SW1 and received by the CPU, which then once stops the electric motor M and sends a control signal for rotating the motor M in the normal rotation direction. The first swing lever 11 is therefore rotated in the C1 direction (clockwise direction) as well as the unlock plate 20 pressed against the first swing lever 11 via the operated piece 23a is rotated in the D1 direction (clockwise direction). The release arm 30 starts to be separated from the pawl 7. Fig. 13 shows a moment when the latch 6 reaches the home position HP1 in which the latch 6 pushes the striker 2 toward an opening end portion, i.e. a portion close to the door 3, of the concave portion 5c of the base 5b with the motor M in a stopped state.

U4( as shown in Fig. 15): return process of the opening mechanism to the original position

**[0046]** When the motor M is kept rotating in the normal rotation direction, the unlock plate 20 rotated in the D1 direction together with the first swing lever 11 finally pushes the origin switch SW2 to turn in ON status via the switch

operating portion 25 (same state as shown in Fig. 7). The CPU stops the motor M based on the signal output from the origin switch SW2 (indicating completion of the unlock operation) at a time of the origin switch SW2 turned in ON status. Then, the CPU enters into the standby mode. At this time, as shown in Fig. 7, the unlock plate 20 may be returned to a state in which the restricted piece 24a of the first control lever portion 24 is pressed against the stopper 51c during a time-lag (corresponding to an overrun amount OU of the motor M shown in Fig. 15) from a time of the origin switch SW2 being pressed and turned in ON status to a time of the motor M actually stopped. If the first swing lever 11 is kept overrunning after the restricted piece 24a is pressed against the stopper 51c, however, the first swing lever 11 becomes not in contact with the operated piece 23a of the unlock plate 20 any more, thereby delaying the following lock operation to start by the closing mechanism 8a. Thus, the overrun amount OU is desirably reduced to a level by which the first swing lever 11 is kept engaging with the operated piece 23a. This structure may be achieved by setting a relative position between the restricted piece 24a and the stopper 51c, and a moving stroke of the operated piece of the origin switch SW2 such that the restricted piece 24a of the unlock plate 20 is just pressed against the stopper 51c when the unlock plate 20 is finally stopped, including the overrun, after the switch operating portion 25 turns the origin switch SW2 in ON status.

**[0047]** Alternatively, the overrun amount OU may be modified so that the first swing lever 11 is stopped before the restricted piece 24a of the first control lever portion 24 is pressed against the stopper 51c. In this case, the restricted piece 24a of the first control lever portion 24 is pressed against the stopper 51c

by the coil spring SP4 for the first time in the process of L2: starting to pull the striker into the latch when the first swing lever 11 is rotated in the C1 direction by the normal rotation of the motor M. In the aforementioned standby mode, it should be noted that the operating pin 12a of the closure arm 12 is positioned out of the rotation locus of the third projection 6c of the latch 6.

**[0048]** According to the above-mentioned present embodiment, the door lock operation and the door unlock operation by the CPU are performed based on the following principle. When the CPU is in the standby mode with the latch 6 in the full-latched state and while the door unlock operation is performed from that standby mode, the origin switch SW2 is constantly in OFF status. The origin switch SW2 is turned in ON status with the completion of the door unlock operation. When the CPU is in the standby mode with the door unlocked and while the door lock operation is performed from that standby mode, the origin switch SW2 is constantly in ON status. The origin switch SW2 is turned in OFF status with the completion of the door lock operation. Then, the initial state in which the latch is in the full-latched state with the CPU in the standby mode is returned.

**[0049]** Further, according to Figs. 5, 7, 11, and 15 in which each process performed in the door lock operation and the door unlock operation is shown along with the overrun amount OL and OU occurring at each final stage of the lock operation and the unlock operation, the origin switch SW2 is turned in OFF status after the completion of the door lock operation and then the standby mode for the door unlock operation is initiated by the CPU. The origin switch SW2 is turned in ON status after the completion of the door unlock

operation and then the standby mode for the door lock operation is initiated by the CPU. The aforementioned condition for the control of the CPU is not changed even if the overrun amount OL or OU of the motor M is large for any reason. Thus, the door lock operation and the door unlock operation are surely performed. According to the present embodiment, practically, the overrun amount OU occurring upon the completion of the door unlock operation (returning operation) is defined extremely small by the stopper 51c for forcedly stopping the overrun of the unlock plate 20 via the switch operating portion 25.

**[0050]** Furthermore, the CPU can perform the control based on the ON/OFF status of the single detecting means at a time of the occurrence of the half-latch signal or the release signal during the door closing operation. Then, the following two advantages may be obtained. First, a structure of the detecting means is simple and thus high reliability and durability of the operation thereof may be assured. The ON/OFF switch SW2 of a cheap pressing type can be employed. In addition, only one switch is required (though the switch SW1 for detecting the status of the latch is required). Next, the control algorithm for the door lock or the door unlock operation is extremely simple, thereby preventing the malfunction thereof.

**[0051]** The embodiment of the present invention is not limited to the above but modified as follows. The release arm 30 may be rotatably supported on the first swing lever 11 instead of the unlock plate 20. In this case, the second swing lever portion 22 and the second control lever portion 23 may be detached from the unlock plate 20 of the present embodiment to be united with the first swing lever 11. Then, the release arm 30 may be rotatably supported on the

second swing lever portion 22 that is united with the first swing lever 11. The unlock plate 20 may be formed with the first control lever portion 24 including the restricted piece 24a to be restricted by the stopper 51c, and the switch operating portion 25 for pressing the origin switch SW2. In this case, the moving plane of the first swing lever 11 and that of the release arm 30 may be required to be positioned different from each other for the door lock operation. Further, the guide hole 31 of the release arm 30 may be formed slightly longer in order to avoid bumping into the control pin 53. Alternatively, contrary to the above embodiment, the closure member (closure arm 12) for the lock operation may be rotatably supported on the operated member (unlock plate 20) while the release member (release arm 30) may be rortatably supported on the operating member (first swing lever 11).

[0052] The movement of the operating member (first swing lever 11) by a driving source is not limited to the rotation with respect to one shaft. The operating member for performing the lock operation and the unlock operation may be constituted to move along a linear rail. For example, an operated member to be operated along the rail may be employed for the unlock operation, and a restricting member for restricting the movement of the operated member in a predetermined position and a detecting means for detecting the operated member positioned adjacent to the predetermined position may be employed for the lock operation for constituting the door lock mechanism according to the present invention.

[0053] The origin switch SW2 is not limited to the above-mentioned ON/OFF switch of the pressing type. It is only required to detect approach of the switch operating portion 25 as the operated member and thus a magnet proximity

switch, a contact for directly electrically detecting the switch operating portion 25, or a light sensor may be employed.

[0054] Further, an emergency operation lever for permitting the latch 6 to return to the home position HP1 by forcedly rotating the pawl 7 in the arrow B2 direction may be provided at a vehicle inner side as a means for directly performing the unlock operation of the door 3 not via the door opening/closing mechanism 100.

[0055] According to the aforementioned embodiment, the striker 2 is provided at the door 3 and the door lock mechanism 4 is provided at the body 1. However, contrary to the above, the striker 2 may be provided at the body 1 and the door lock mechanism 4 may be provided at the door 3. In this case, a microswitch for sending the release signal to the CPU when the open handle is slightly operated can be provided at the open handle arranged at the outside of the door 3. Further, if the door unlock operation is not performed by the door opening/closing mechanism 100 due to a defect of the power supply from the battery in case that the user even operates the microswitch, the unlock operation of the door 3 can be performed by the pawl 7 connected to the open handle via a cable to be forcedly rotated in the B2 direction, which is caused by the open handle further widely operated. The door opening/closing mechanism 100 according to the present invention may be adopted not only to the back door as mentioned above but also a side door and the like.

[0056] Therefore, the door lock apparatus of the present invention may surely and constantly perform the lock operation and the unlock operation with a simple structure regardless of the amount of the overrun of the operating member.

[0057] The principles, preferred embodiment and mode of operation of the present invention have been described in the foregoing specification. However, the invention which is intended to be protected is not to be construed as limited to the particular embodiment disclosed. Further, the embodiment described herein is to be regarded as illustrative rather than restrictive. Variations and changes may be made by others, and equivalents employed, without departing from the spirit of the present invention. Accordingly, it is expressly intended that all such variations, changes and equivalents which fall within the spirit and scope of the present invention as defined in the claims, be embraced thereby.